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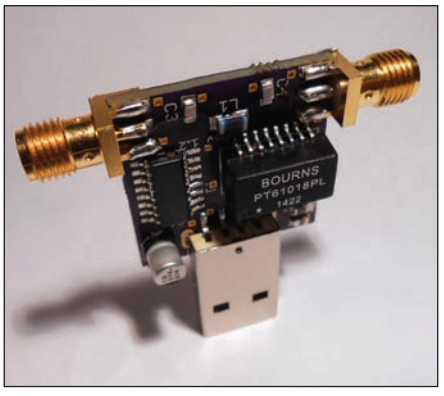
# An HF Receive Converter for RTL-SDRs

**Jenny List G7CKF describes an HF converter that will allow you to receive HF signals on one of the readily available RTL dongles.**




**You are probably familiar with RTL2832-based USB TV dongles used as cheap SDR receivers. They represent amazing value but lack HF reception without extensive modification or an HF converter. This article describes such an HF converter, with a 50MHz local oscillator for a VHF receiver. It uses a CMOS switch IC as a mixer and an inexpensive dual Ethernet transformer instead of requiring any coils to be wound.**

The converter was conceived originally as an entry for a contest on the popular Hack A Day website, all of whose entries had to fit on a PCB of one inch square or less. This dimension represents the cheapest online deal for having your own prototype PCBs made. Sadly it did not win a prize.

## Design Choices

My aim was to make a converter as simply as possible without too many sacrifices. It was important to avoid overloading the mixer with either signal or local oscillator and to adequately reject out-of-band signals.

The circuit appears as **Fig. 1**. The mixer is a 74VHC4053 CMOS switch. It has a bandwidth of more than 100MHz and is resistant to overloading. Its local oscillator input is at logic level, thus also avoiding overloading there.

As a balanced mixer, this requires an RF transformer on both input and output. A dual Fast Ethernet transformer with a 1 to 100MHz bandwidth does this job.

Out-of-band rejection comes from a 3-element lowpass filter with a corner frequency in the low-30s of megahertz.

SMA connectors were chosen for input and output, as the most prevalent connector used with SDRs.

The 5V power requirement for the converter is taken from a USB plug.

## Construction

This is a surface-mount design that fits neatly on a 25mm square double-sided PCB. The drawings **Figs. 2** and **3** show the track patterns and component placement on the bottom and top respectively of the PCB.

Most components are on the top of the board. Start on this side with the passive components – first the R1/R2/C5 bias network and then the filter C3, C4, and L1. Coat the pads in flux, place the component on them, then hold it in place with a small screwdriver while soldering each end. Only unpack one component at a time, the one on which you are working.

Inductor L1 is more challenging because its contacts do not extend onto its top surface. Use plenty of flux and take care to bring your soldering iron in from the side, pushing a blob of solder under the overhanging epoxy layer.

You can now solder the electrolytic capacitor C1, mixer IC1 and, finally, the transformer T1. Both IC1 and T1 should be held in place on their flux-covered pads while one corner is tacked down with a blob of solder, then molten solder should be run along each row of pins. Pay close attention to their orientation and look carefully for solder bridges. Remove any of these you find along with any excess solder with desolder wick.

Capacitor C2 and the oscillator OS1 can now go on the underside. Coat their pads with flux, then hold them in place with the end of a small screwdriver while soldering them. Pay close attention to the orientation of OS1 and if it has a metallised top surface, take care not to bridge your solder onto it. Again, remove any solder bridges with desolder wick.

Now attach the connectors. The USB plug goes on top. Snap it into place with the earth tabs through the holes. Check that it locates with the board edge and that its contacts are on their pads. The contacts are widely enough spaced to solder individually.

The SMA connectors fit onto the board edge and should be soldered on both top and bottom of the board. The centre pin should be on the top.

You should now have a completed board. Examine it carefully for solder bridges and remove any you find with desolder wick.

You should measure the current consumed by your board with a 5V PSU and a multimeter. A correctly assembled board should consume about 19mA.

## Operation

The board uses a spare USB socket and the output should be wired to your SDR with an appropriate cable. Then attach an HF antenna to the input and run your SDR software.

Frequencies from 0 to 30MHz appear on the output of this converter as 50 to 80MHz so that, for example, 7MHz appears at 57MHz. Transformer roll-off below 1MHz and receiver overloading from the local oscillator mean strong MW broadcast stations are all you are likely to hear in the 50 to 51MHz range.

## Components

The capacitors and resistors are widely available. Inductor L1 is an Abracon part, Mouser part 815-AISC-1206-R22J-T, but

## Parts List

| Part | Value | Package | Description |
|---|---|---|---|
| C1 | 10µF | PANASONIC_B | Electrolytic capacitor |
| C2 | 0.1µF | C0805 | Ceramic capacitor, 0805 package |
| C3 | 180pF | C0805 | Ceramic capacitor, 0805 package |
| C4 | 180pF | C0805 | Ceramic capacitor, 0805 package |
| C5 | 0.1µF | C0805 | Ceramic capacitor, 0805 package |
| R1 | 2.2kΩ | R0805 | Resistor, 0805 package |
| R2 | 2.2kΩ | R0805 | Resistor, 0805 package |
| L1 | 220nH | L1206 | Inductor, wirewound, 1206 package |
| IC1 | 74VHC4053 | SO16 | Triple CMOS SPDT switch |
| JP1 | USBA-SMD-MALE | USB-A-SMT-MALE | SMD USB plug |
| OS1 | 50MHz | 7.2X5.2-4-PAD | 5V crystal oscillator, 7mmx5mm |
| SMA1 | ANT | SMA-EDGE | Edge-mount SMA socket |
| SMA2 | OUT | SMA-EDGE | Edge-mount SMA socket |
| T1 | Bourns | PT61018PEL | 16-pin SMD dual Fast Ethernet transformer PCB |

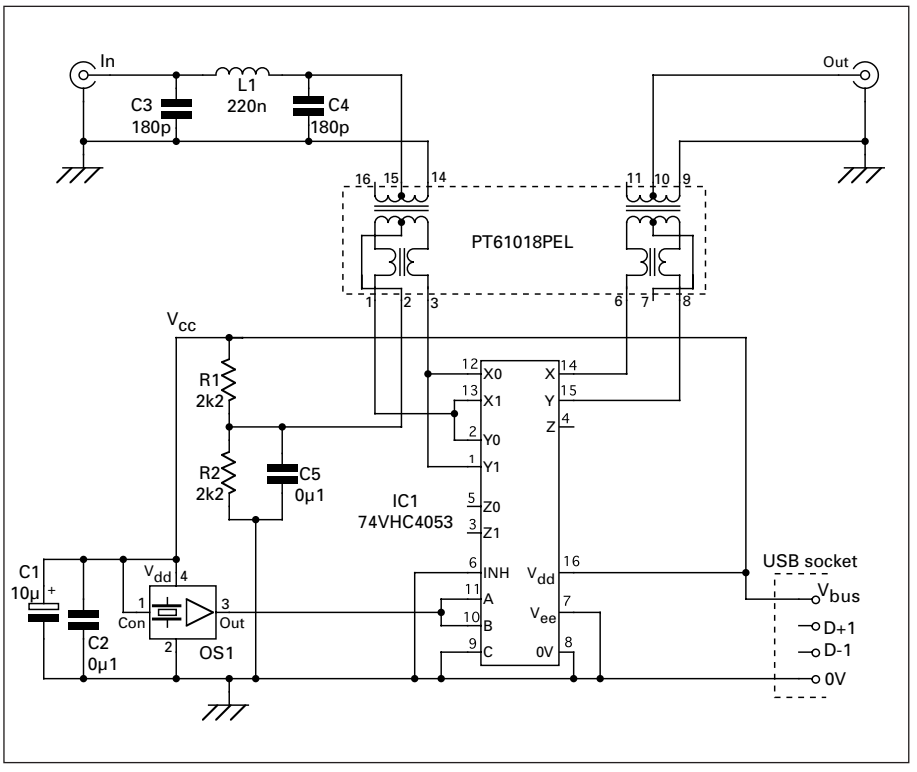



**Fig. 1: Circuit diagram of the receiver converter.**

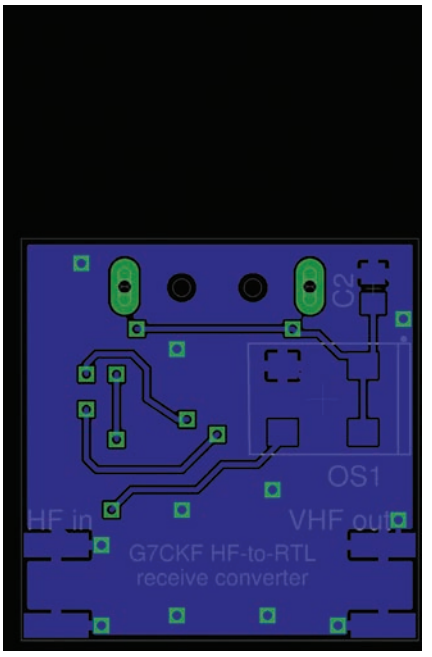



**Fig. 2: Component placement on the bottom of the PCB.**

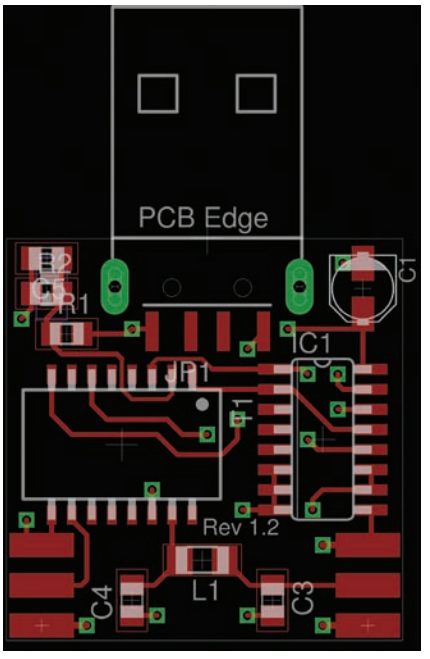



**Fig. 3: Component placement on the top of the PCB.**

equivalent wirewound parts would be suitable. Multilayer inductors will deliver reduced performance.

The mixer IC is a 74VHC4053 in an SOIC-16 package, widely available.

The transformer is a Bourns PT61018PEL, Mouser part 652-PT61018PEL. Close equivalents are made by multiple manufacturers. A Wurth 749013010, RS part 522-5917 would be suitable, for example, or even salvage one from a dead Fast Ethernet card. Be wary if you use another transformer; these devices contain a common-mode rejection choke and some have a 'mirror image' pin-out. Ensure the common-mode choke is on the mixer side.

OS1 is a 7x5mm SMD 50MHz 5V crystal oscillator, widely available. **Very important:** find a 5V part, avoid similar 3.3V parts. I used a TXC 7W-50.000MAB-T, Mouser part 717-7W-50.000MAB-T. An equivalent is AKER S75005-50.000-X-15, RS part 671-9854.

The connectors are widely available. Mine came from Toby Electronics: **www.toby.co.uk**

Be sure to source edge-launched SMA connectors that match your PCB thickness.

My PCB came for a very reasonable price from OSH Park in the USA and can be found here: **https://oshpark.com/shared_projects/Vfd9X8z1**

All the files related to the project are also on the web at the address below. EAGLE CAD is a free download if you don't already have it. The OSH Park link is the exact PCB I had made, shared for anyone who wants to order one. Their cheapest deal gets you three boards plus postage for $5, or about £3.50, which is very good value indeed. **https://github.com/JennyList/LanguageSpy/tree/master/Hardware/one-inch-HF-to-VHF-converter**